Applied Machine Learning with Big Data
"EE 6973"

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Deep Learning Best Practices

Bias and Variance

Training Data Set **Test Data Set**

Human Level Error = 5%
Training Error = 30%
Test Error = 33%

What to do next ????

Bigger Model
Training Longer or Use GPU (Faster Systems)
New Model architecture

Human Level Error = 5%
Training Error = 7%
Test Error = 30%

What to do next ????

"Over fitting problem"

More Data
Regularization
New Model architecture

End-to-End Deep Learning

Simple (Classification or Regression)

- Movie Review → Sentiment
- Image → Object Recognition

"DL, CNN, RNN" models

2nd Major Trends

- Image → Caption
- Audio → Transcript
- English → French
- Parameter → image

K-Means Clustering

3 Types of Learning

Supervised

- Learning from labeled data
- E.g., Spam classification

- Classification
- Regression
- Ranking

Unsupervised

- Discover structure in unlabeled data
- E.g., Document clustering

- Clustering
- Hidden Markov Models

Reinforcement

- Learning by “doing” with delayed reward
- E.g., Chess computer

What is Clustering?

Attach label to each observation or data points in a set

You can say this "unsupervised classification"

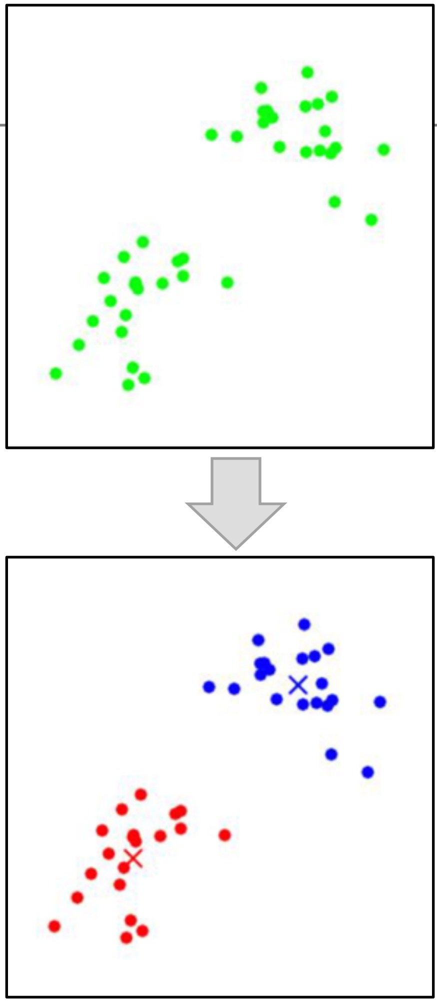
Clustering is alternatively called as "grouping"

Intuitively, if you would want to assign same label to a data points that are "close" or "similar" to each other. Thus, clustering algorithms rely on a distance metric between data points

For example: Euclidean distance

$$E = \Sigma_{k=1}^{K} \Sigma_{\mathbf{x} \in C_k} d^2(\mathbf{x}, \mathbf{m}_k)$$

$$d^2(\mathbf{x}, \mathbf{m}_k) = \sum_{n=1}^{N} (x_n - m_{kn})^2$$



NP-hard combinatorial optimization problem

In how many ways can we assign *K* labels to *N* observations?

For each such possibility, we can compute a cost. Pick up the assignment with best cost.

Number of possible classes:

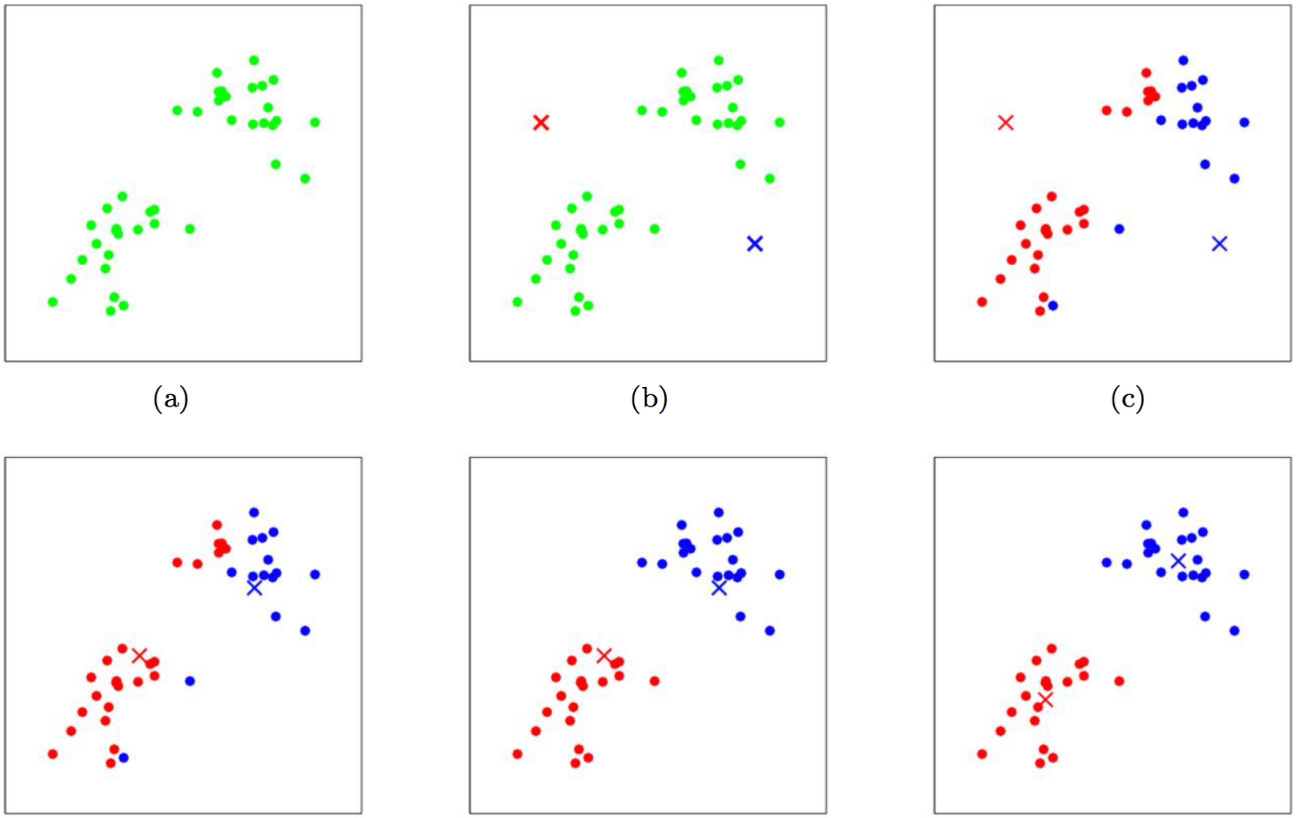
$$S(N,K) = \frac{1}{K!}\sum_{k=1}^{K}(-1)^{K-k}\binom{K}{k}k^N$$

What is K-means Clustering?

k-means clustering aims to partition n observations into **k clusters** in which each observation belongs to the **cluster** with the nearest **mean**, serving as a prototype of the **cluster**.

- An unsupervised clustering algorithm
- "*K*" stands for number of clusters, it is typically a user input to the algorithm; some criteria can be used to automatically estimate K. It is an approximation to an NP-hard combinatorial optimization problem but Easy to implement.
- *K*-means algorithm is iterative in nature and works only for numerical data

Example



(a) (b) (c) (d) (e) (f)

K-Means

The *K-means* algorithm: a heuristic method

- K-means algorithm: each cluster is represented by the center of the cluster and the algorithm converges to stable centroids of clusters.

- K-means algorithm is the simplest but computationally expensive partitioning method for clustering analysis

K-Means

Given the cluster number K, the K-means algorithm is carried out in three steps after initialization:

Initialization: randomly set seed points

1) Assign each object to the cluster of the nearest seed point measured with a specific distance metric

2) Compute new seed points as the centroids of the clusters of the current partition (the centroid is the canter, i.e., *mean point*, of the cluster)

3) Go back to Step 1), stop when no more new assignment (i.e., membership in each cluster no longer changes)

K-Means Algorithm

Randomly initialize K cluster centroids C1, C2, …, Ck

Repeat {

for i= 1 to N

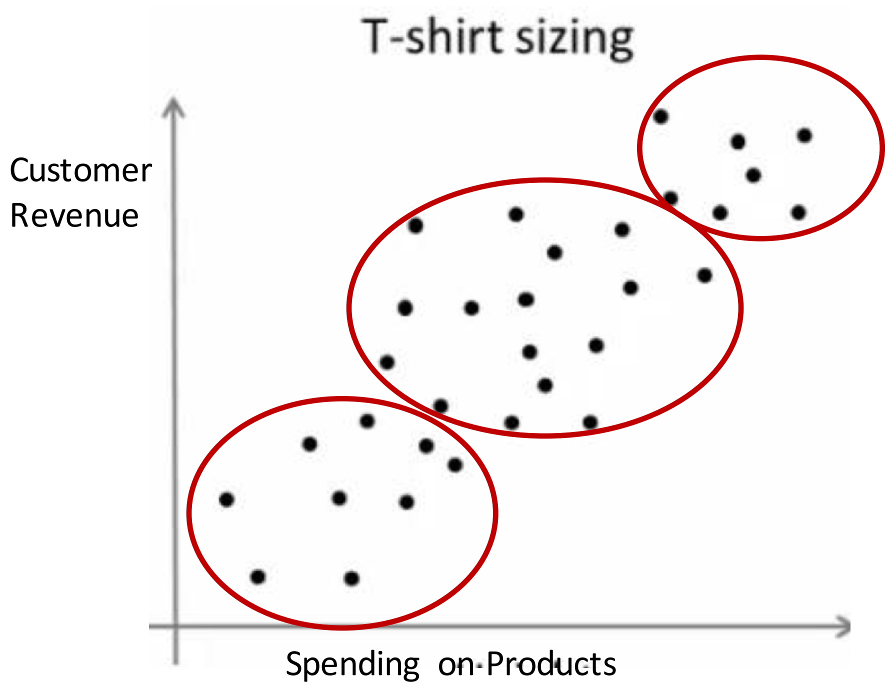
xi := Label as the closest cluster centroid

for k= 1 to k

Ck := mean of points assigned to cluster k

}

Example: Customer Segmentation based on spending and revenue "T-shirt sizing"



T-shirt size problem